

First observations of Fiji Petrel *Pseudobulweria macgillivrayi* at sea: off Gau Island, Fiji, in May 2009

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SUMMARY.—The first unambiguous observations of Fiji Petrel *Pseudobulweria macgillivrayi* at sea are documented with photographs. The species' behaviour, jizz and flight are described, presented together with comments on confusion species, especially Bulwer's *Bulweria bulwerii* and Jouanin's Petrels *B. fallax*, and Christmas (Kiritimati) Shearwater *Puffinus nativitatis*. Preparations for the expedition, why a given sea area was chosen, the 'recipe' and use of 'chum' as an attractant, and the methods used for counting petrels are explained. The four specimens of Fiji Petrel were studied in detail and records of grounded birds, from the only known location, Gau Island, Fiji, were reviewed and their ageing re-considered. These data permit us to speculate on this petrel's breeding season, which is highly relevant to the future conservation of this Critically Endangered species.

We report the results of pelagic work off Gau Island in May 2009, during which our prime objective was to observe Fiji Petrel *Pseudobulweria macgillivrayi* in its marine environment. Until now the species has been identified only on Gau itself, where the type specimen was collected in 1855 (Gray 1859). Thereafter the species went unrecorded for nearly 130 years until one was caught in 1984 (Watling & Lewanavanua 1985). Considerable but unsuccessful efforts have been made to search for nesting sites on Gau, but several grounded birds have confirmed its continued presence (Priddel *et al.* 2008). Because Fiji Petrel is exceptionally rare and extremely poorly known (Bourne 1965, Imber 1986, Bretagnolle *et al.* 1998, Brooke 2004), being listed as Critically Endangered (IUCN 2009), any new data concerning range and abundance are vital to its conservation.

The Fiji Islands are in western Polynesia, c.2,000 km north of New Zealand and east of Australia. Volcanic Gau (18°01'S, 179°17'E; 136 km²) is 57 km east of the main island of Viti Levu and is Fiji's fifth-largest island. Rugged and mountainous, Gau rises to 715 m, has c.50% forest cover, and supports a human population of 3,000 (Watling 1985, Priddel *et al.* 2008). The people of Fiji, especially Gau, are proud of their petrel, known locally as *Kacau ni Gau*; it featured on the former Fijian \$50 banknote, and is the logo of Air Fiji. Because John MacGillivray was not involved with the holotype's collection (Watling & Lewanavanua 1985, Bourne 2007) we endorse Fiji Petrel as the species' English name.

Several organisations over the years have supported the National Trust of Fiji's efforts to conserve the species, which have chiefly involved awareness raising and training people to give 'first aid and release' to any grounded birds attracted to village lights (*cf.* Priddel *et al.* 2008). There has also been an emphasis on gaining data from dead and / or grounded birds to assess the timing of breeding (Priddel *et al.* 2003). The idea to search deep oceanic waters was originally proposed and instigated by HS, in 2005, with a second expedition by HS, TP, JK and DW in 2008 (Appendix 3). Our objectives were to gather data on identification and behaviour of this virtually unknown *Pseudobulweria*. The May 2009 expedition was one of several field surveys within a new conservation project planned by NatureFiji-MareqetiViti (NFMV 2009a) in partnership with the National Trust of Fiji. The main

objective is to learn more about Fiji Petrel, and to find and protect its nests from the threat posed by rats, feral cats and an expanding population of feral pigs.

Methodology

Finding Fiji Petrel at sea was no accident; the sea area surveyed and the methods used were planned following surveys in 2005 and 2008. We used a method of attracting petrels close to the boat that HS and TP had developed and used successfully elsewhere in the world.

Timing.—The expedition dates were 13–22 May 2009. Prior to this, we examined the four specimens of Fiji Petrel collected on Gau (Appendix 1), reviewed the work of Priddel *et al.* (2008) and chose the period at sea based on two grounded birds. In early May 2005 two crashed onto village roofs, one of which was caught, and in April 2007 an adult female was caught. We concur with Bourne (1981) and Priddel *et al.* (2008) that the breeding season is likely to be sometime from April, and that in May breeders might be supplemented by the presence of non-breeders. May was chosen as the month when most birds might be encountered at sea, close to the island. May marks the transition between the cyclone season and the onset of the south-east trade winds, so major storms would be unlikely. We also took into account the lunar cycle, knowing that we would commence the work when the moon was near full, at which time fewer birds were likely to be in the vicinity. However, over ten days at sea we should learn if there were changes to numbers (and species) relating to the lunar cycle. Many petrels, being nocturnal at their colonies, tend to return in darkness to avoid predators, but local conditions, like cloud cover and stage of breeding, also determine arrival. The rather full moon at the outset might show that petrels use the period of darkness before the moon rises to reach nearby waters earlier in the day.

'Chumming'.—The objectives were to determine the following. (1) Whether Fiji Petrels can be observed at sea and to provide information on their identification and behaviour. (2) If photography can enable adults and juveniles to be distinguished, thereby contributing to an assessment of the timing of breeding. (3) Whether Fiji Petrels can be attracted, in sufficient numbers, close to a small boat to enable capture for transmitter attachment. We plan three trips before the technique is reviewed. Frozen 10-kg blocks of 'chum' were used. Each block comprised 60% fish offal (6 kg), cut into small pieces and mixed with 10% very dense fish oil (one litre) to which 30% water (three litres) was added. In addition, we used large-fish livers cut and mixed with fish oil and popcorn. In total, we transported 1,000 kg of 'chum' and 100 kg of the liver mix to the island in freezers. The 'chum' was prepared a few weeks ahead by volunteers from NatureFiji-MareqetiViti. The 'chum recipe', quantity needed and its use was piloted off Gau in 2008, based on previous work (Shirihai 2008a) where it was found that dissolving frozen blocks act as the principal attractant, whilst the liver pieces, which float naturally, are added, as required, to maintain the petrels' interest. Frozen 'chum' blocks persist for up to 1.5 hours creating a pungent and constant oil slick, with the aroma and visible slick being pushed downwind, attracting petrels from some miles away. One or two blocks, plus a small amount of liver, were dropped overboard at intervals of 1.0–1.5 / hour. We 'chummed' for c.50 hours during the ten days with daily sessions lasting a mean of five hours.

Study area.—Given the location of Gau in relation to neighbouring islands, its bathymetric setting based on ocean charts, and the prevailing winds, we concentrated effort in the ocean due south of the island. We surveyed an area, c.25 nautical miles (nm) from Gau, mainly at 18°27.293'S, 179°10.775'E (see also Results). This area was selected based on successful pelagic work with Zino's Petrel *Pterodroma madeira* off Madeira, Atlantic Ocean

(Shirihai 2008b, 2009), given similarities between the islands' topography, the approach of birds using the dominant winds, and the location of records of grounded birds in relation to the breeding sites. With Kadavu to the south-west, Viti Levu to the west, an arc of islands—Ovalau, Batiki, Wakaya to the north and Moala and Matuku to the east—a direct passage from the open ocean converged on Gau. In 2005 and 2008 we found an afternoon / evening passage of petrels arriving from the south-west, bypassing Gau to the south, which we hoped to attract to the 'chum' as 'trigger species', so that any feeding frenzy might attract Fiji Petrels. May marks the beginning of the south-east trade winds, which would aid petrels returning to the island from the south and south-west, whilst most records of grounded Fiji Petrels are from the south-west of the island. The study area chosen is shown in Fig. 1.

Vessel.—We were based at Nukuloa village on Gau and travelled daily to the survey area in an open, sports-fishing speedboat, the privately chartered *HiFlyer* (12 m, two 225-hp outboard engines). Averaging 22 knots, we covered over 550 nm during the ten days, returning to Gau prior to dark to safely enter the narrow Nagali passage.

Camera equipment and GPS.—We used the most advanced camera equipment currently available, including Canon Mark3 D and DS, and 300-mm / F2.8 and 500-mm / F4 lenses,

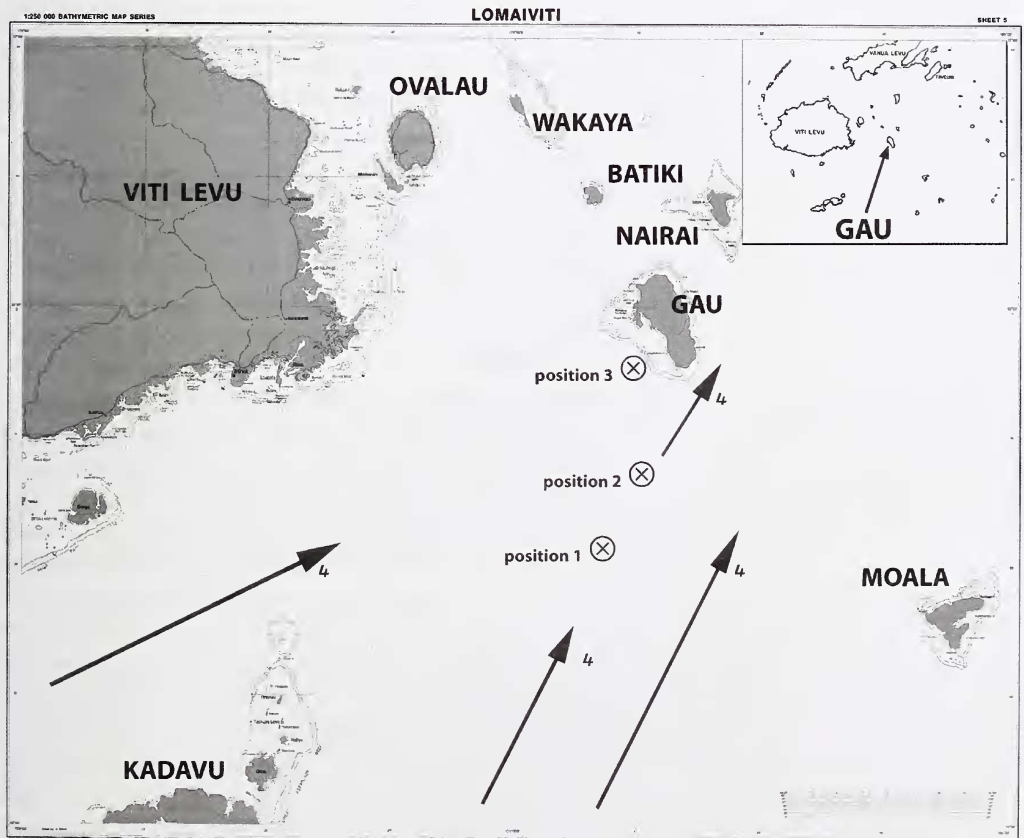


Figure 1. Map showing Gau and locations of Fiji Petrels *Pseudobulweria macgillivrayi*. Position 1 (c.25 nm off Gau), Fiji Petrels 2, 3 and 6 recorded. Position 2 (c.15.0–17.5 nm off Gau), Fiji Petrels 1 and 5 recorded. Position 3 (c.4–10 nm off Gau), Fiji Petrels 4, 7 and 8 recorded. 4. Arrows show the direction of afternoon passage of Tahiti *P. rostrata* and Collared Petrels *Pterodroma brevipes* though this varied with wind, weather and cloud cover. See text for rationale for choosing the survey area.

as well as Nikon D 700, 300 mm / F4.0 and 1.7 converter. We used a mobile GPS, Garmin Colorado 300 with a marine chart programme, to waymark positions, travel between locations, and log sightings.

Data collection.—Usually the boat drifted just off the ‘chum slick’, permitting birds to move freely along the ‘slick’ and to feed undisturbed, as well as affording us the best angle for observing birds already attracted and those incoming. We counted birds and their activity during sessions of 30–60 minutes each. For each species we recorded the estimated number of birds during the session and the maximum number seen at one time. For consistency the same observer made virtually all counts. These counts are relevant to the commoner species, especially Tahiti Petrel *Pseudobulweria rostrata* and Collared Petrel *Pterodroma brevipes*, and, most importantly, can be directly compared to the numbers of Fiji Petrel in any period. Also, ten birds with distinct plumage due to moult and / or missing remiges were selected, and their visits to, and duration at, the ‘chum’ noted, which proved useful to determine overall numbers. At the end of each day we agreed on conservative totals. This method is the same as that recently used in Cape Verde and Madeira, where counts during ‘chumming’ were suggested as a tool to monitor the *Pterodroma feae* complex (Bretagnolle *et al.* in prep. a). Here, only our basic data are presented (Appendix 3, Table 2); additional data will be used in further research, currently being planned, and a future publication on the region’s petrels.

Each Fiji Petrel seen was afforded a number with individual description, behavioural notes and photographs used in the analyses below. Prior to the work, we agreed the manner for accepting any sightings of the species; given various levels of relevant field skills, only when four of us (HS, TP, JK, DW) had observed a bird sufficiently for all key features to be detected, and were unanimously agreed, was an identification considered certain. We photographed four of the eight Fiji Petrels we saw. All other petrels seen during the expedition, and in 2005 and 2008, are recorded in Appendix 3; for those observed in 2009 see Table 2. Also we studied plumages of the polymorphic Collared Petrel (Watling 1986a), particularly variation within darker morphs (>200 birds were photographed).

Results

Fiji Petrel sightings.—This section records sightings of Fiji Petrels and other tubenoses (see Appendix 3 and Table 2 for all species and estimated numbers). **13 May**—Fiji Petrel 1 seen at 10.50 h, at 18°18.722’S, 179°13.515’E (c.15 nm off Gau), flying in quite high arcs west; Fiji Petrels 2–3 visiting ‘chum’ at 18°27.293’S, 179°10.775’E (c.25 nm south of Gau), for timings see below, both photographed; during each appearance, per session, there were also c.20 (max. 11 at once) Tahiti Petrels, c.20 (13) Collared Petrels, two Gould’s Petrels *Pterodroma leucoptera*, one Mottled Petrel *P. inexpectata* and a Wedge-tailed Shearwater *Puffinus pacificus*. **14 May**—Fiji Petrel 4 at 17.29 h, at 18°12.020’S, 179°13.552’E (c.10 nm off Gau), appeared to be heading towards Gau. **16 May**—Fiji Petrel 5 at 12.15–12.25 h, visiting ‘chum’ at 18°21.968’S, 179°14.855’E (c.17.5 nm south of Gau), photographed; also observed were c.5 (max. 3) Tahiti Petrels and a Collared Petrel. **17 May**—Fiji Petrel 6, at 11.25–11.35 h, visiting ‘chum’ at 18°27.293’S, 179°10.775’E (c.25 nm south of Gau), photographed, and its behaviour described below; also observed were c.20 (max. 8) Tahiti and c.20 (5) Collared Petrels, and single Sooty *Puffinus griseus* and Wedge-tailed Shearwaters. En route to Gau, at 17.45 h, Fiji Petrel 7, at 18°06.900’S, 179°15.424’E (c.2 nm outside the reef and c.4 nm from Gau), clearly seemed to be on approach, flying north to north-west, and perhaps adopting a ‘holding’ position, awaiting darkness before flying to the island. We spent time inside Gau lagoon, off the village of Nawaikama, facing a valley and the island’s highest peak, to check

if this or any other bird arrived at dusk, but none was seen. **18 May**—Fiji Petrel 8, at 17.30 h, at 18°09.523'S, 179°13.909'E (just 3.6 nm from the reef and c.5 nm from Gau), was flying north-east, and again appeared to be adopting a 'holding' position, waiting for darkness.

It is premature to conclude much from these observations, but we noted two main activities. (1) Towards dusk, post-17.30 h, Fiji Petrels 4, 7 and 8 were closer to land, off the south-west of the island, presumably before flying in under complete darkness. All four birds photographed were adult-like (see Ageing and moult), i.e. presumably breeders. (2) During the day, some (Fiji Petrels 2, 5 and 6) were south off the island (mostly c.20 nm and more), and were attracted to the 'chum'. There is a possible correlation between the number of Fiji Petrels and numbers of commoner petrels visiting the 'chum'.

Behaviour at sea and response to the boat.—Fiji Petrel is rare and our encounters too few to permit a detailed description of its behaviour at sea. However, we can state that the species appears to ignore boats: of the eight sightings, four were en route to, or in the vicinity of, Gau and these birds showed no interest in the boat, as sometimes happened with Tahiti Petrels. At the 'chum', where the other four individuals were seen, Fiji Petrel seemed to tolerate our small boat, with bird 2 approaching food on the surface just a few metres away several times and once flying over the bow. The duration of uninterrupted visits by the four birds attracted to the 'chum' was 2–10 minutes (mean c.7.3 minutes of six visits). Bird 2 revisited twice, as verified by photographs: the first visit at 14.21–14.28 h (c.8 minutes) was followed by a gap of seven minutes, reappearing at 14.35–14.40 h (c.6 minutes), before another gap of c.13 minutes then returning at 14.53–15.01 h (c.8 minutes). It was in the vicinity for c.44 minutes. The two other Fiji Petrels visited the 'chum' once only. Bird 3 was seen for two minutes, arriving at 17.24 h as dusk approached and we were preparing to depart; it might have stayed after our departure. Our impression was that this bird's rather brief, hesitant approach was determined by the larger Tahiti Petrels, who could be aggressive at the 'chum', calling loudly when squabbling. Fiji Petrel may be subordinate in such a melee. Bird 6 was observed to take some offal, only to then be chased by a Tahiti Petrel and, after landing again, drop the food and depart. The foraging technique of Fiji Petrels at 'chum' is similar to *Pseudobulweria rostrata* and *P. becki* that HS and TP have observed in the Pacific. Fiji Petrels usually approached from downwind and slowly zig-zagged over the 'slick', suddenly changing direction to drop onto a small floating morsel (14 such approaches were observed by four birds). Also, bird 6 landed briefly on the water with wings held upwards and partially opened, in a manner used by *P. rostrata* and *P. becki*. Fiji Petrel, like gadfly petrels, appeared to be attracted to the 'chum' using both smell and sight. The bird that stayed on the 'chum' longest (bird 2) was observed on the day that we recorded the largest numbers of other petrels.

Ecology and conservation

When does Fiji Petrel breed? The protection of this Critically Endangered species is the main objective of all our activities. To enable this, an understanding of the breeding cycle is essential in order that resources can be targeted to the period when active nests are most likely to be found and protected. Any data on moult and / or age of photographed birds can contribute to this (see Ageing and moult; Appendix 1). Priddel *et al.* (2003, 2008) relied primarily on the presumed age of the holotype as the key to the breeding period, however, we can no longer be sure of this bird's age and have therefore excluded it from our calculations.

Fig. 2 shows records of grounded petrels that Priddel *et al.* (2008) considered confirmed, with the addition of the 2009 bird. It shows also the six we examined (as specimens or in

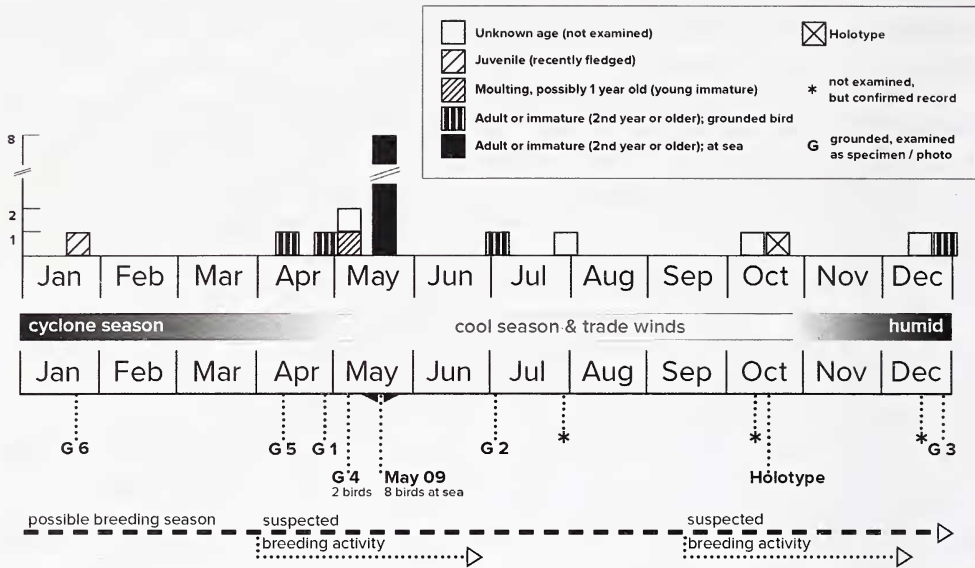


Figure 2. Records of Fiji Petrels *Pseudobulweria macgillivrayi* from Gau Island, Fiji, and nearby seas 1855–2009. For details of grounded birds see Appendix 1 (G = grounded Fiji Petrels 1–6). The eight birds seen at sea in May 2009 are also shown. Centre, the winter cool season with trade winds, and the hot and humid cyclone season are illustrated. Below, months when breeding activity is suspected based on ages of grounded birds (see legend) and our observation of birds close to shore.

photographs), and for which ages can be ascertained using moult. Of ten Fiji Petrels (six grounded 1984–2009 and four photographed at sea) nine were adults or immatures (second-year or older) and only one a juvenile (January 2009). Grounded records are mostly in April–July, with fewer in October–January, and none in August–September or February–March. With so few records, it is premature to conclude that the breeding season of Fiji Petrel falls during a given climatic cycle (Fig. 2), although the majority of records are from the cool season during the trade winds.

Priddel *et al.* (2008), following Bourne (1981) and Imber (1986), assumed Fiji Petrel to be essentially an austral winter breeder and, with the holotype collected in early October believed to be a recently fledged juvenile, eggs would be laid sometime in June (based on 118 days estimated from laying of the egg to fledging for similar-sized petrels). Our data, however, tend to suggest a protracted breeding season, perhaps lasting most of the year. The records are not spread evenly through the year but dates, moult and behaviour suggest two periods of apparent breeding activity. *April–July*: three of the six documented grounded birds, adults (or non-breeding immatures), were from this period, including that on 4 May, which was the only bird in active moult showing, apparently, juvenile-retained remiges, suggesting a moulting youngster. Since non-breeding immatures may arrive at the island a few weeks after breeding adults, we speculate that adults might arrive during April, with breeding probably commencing in May (or even mid April) including a pre-laying exodus. The breeding season of petrels of this size may extend *c.* 5 months (with pre- and post-breeding activities) yet to date there are no confirmed records for August. *October–January*: the discovery of a very fresh, recently fledged juvenile on 19 January 2009 suggests that breeding also commences from October (or even September). However, there are too few records to conclude that the breeding season is continuous, or contains two peaks, or even to identify when the bulk of breeders probably come ashore. For now, we

suggest searching for nests from late April and May and that these months might be more profitable for spotlighting, capturing birds for telemetry, and for the proposed use of trained dogs for locating breeding sites (Priddel *et al.* 2008).

How rare is the Fiji Petrel? We observed only a few Fiji Petrels. This was despite choosing what we considered to be the optimum month, and a period when the moon went from almost full to almost new. We worked a corridor, from positions far offshore to close inshore, from where petrels approached Gau. We used large amounts of 'chum', targeting all petrels, and we believe few birds in the vicinity would not have been attracted at some time. The present evidence is that few Fiji Petrels survive, that immediate efforts to find the nest sites are needed, and prompt, effective protection is urgently required before it is too late. Recent work with *Pterodroma madeira* off Madeira (Shirihai 2009) recorded 13 birds at sea in eight days, where a comparatively well-known population is estimated at c.80 pairs (Zino *et al.* 2008). Contrast this with our figures for Fiji Petrel and the population might therefore be <50 pairs. We endorse Brooke (2004) who wrote 'The species' population is unknown; it may be only a few tens of individuals'.

Two new threats to the species' survival are manifest. The first is the reports from islanders of a burgeoning population of feral pigs that are now ranging into summit forests—in the 1980s there were no feral pigs on Gau (Watling 1986b). Secondly, we observed several Tahiti Petrels, and a Kermadec Petrel *Pterodroma neglecta*, with damaged wings (partially broken and twisted inner primaries) suggesting that these birds had become entangled with long-lines when scavenging at fishing vessels. As Fiji Petrels are attracted to 'chum', they might well be exposed to the dangers of long-lining.

Description

Until now, the plumage of Fiji Petrel had been described only from specimens, and its characteristics and behaviour only assumed. Here we provide a full description of Fiji Petrel based on the eight birds we saw, which observations confirm that structurally and behaviourally it is a typical *Pseudobulweria*, and given good or prolonged views should be readily identifiable at sea.

Size and proportions.—A typical *Pseudobulweria* with large bill, proportionately long wings, and elongated rear body and tail. Total length c.29 cm and wingspan 73 cm (based on the recently grounded bird, January 2009). Full measurements are given in Table 1; see also Figs. 3–8. We observed Fiji Petrels directly alongside *P. rostrata*, the sole *Pseudobulweria* known to overlap in range, and our impression was that *macgillivrayi* is structurally a miniature version of *rostrata*. This is confirmed by actual measurements of body length, wingspan, wing and tail, which compared to data from *rostrata* (Villard *et al.* 2006) reveal Fiji Petrel to be c.27% smaller but with body mass 50% that of *rostrata*, adding to the field impression of a smaller delicate bird. It has several features that differ structurally though; the rear body, beyond the trailing edge of the wing, is very elongated, slim and tapers to the pointed tail, the tip of which is blunt and rounded (Figs. 3–5). The wings appear proportionately narrower and more pointed than Tahiti with the 'hand' (primaries) tapering markedly and sometimes appearing disproportionately longer than the 'arm' (secondaries) by c.35% (Figs. 3–6, 8). The bill is typical of the genus, being noticeably smaller than that of Tahiti (c.25% shorter), but appears more compressed forward of the nostrils at the culmen and the maxillary nail more bulbous (Figs. 3, 5–7). In profile the head looks rather square, with a 70°-slope to the forehead and flattish crown (Figs. 6–7). Its long narrow neck (e.g. Figs. 6–8) further enhances the slim, elongated impression of Fiji Petrel. Overall it never has the heavy-bodied appearance of Tahiti Petrel. On several occasions the feet of Fiji Petrel were

TABLE 1

Biometrics of the four specimens of Fiji Petrel *Pseudobulweria macgillivrayi*. All measurements by HS. Body mass data taken from the capture protocol. For wing formula see below.

	Wing		Tail	Tail graduated	Tarsus	Bill to feathers	Bill depth at feathers	Bill depth at top of hook	Bill depth at hook base	Total length	Weight (g)
	Right	Left									
Bird 1 ♂	205.5		83.7	23.9	36.0	25.8	12.0	8.5	8.5	280.0	
Bird 2 ♀	216.0	218.0	91.0	24.0	36.0	27.4	12.6	10.2	10.2	285.0	120
Bird 3	215.0					25.0		9.5			
Bird 4	225.0	225.5	90.0	29.0	37.8	27.4	12.2	10.3	10.3	288.0	145
Range	205.5–225.5		83.7–91.0	23.9–29.0	36.0–37.8	25.0–27.4	12.0–12.6	8.5–12.3	8.5–10.3	280.0–288.0	120–145
Mean	217.5		88.2	25.6	36.6	26.4	12.3	9.6	9.6	284.3	132.5

- Bird 1 Holotype, Natural History Museum (Tring), October 1855; examined June 2008. Wing formula: p10 (outer) 3.1 mm < tip (=p9 longest) [p10 = p8/9, closer to p8]
- Bird 2 In possession of DW, collected 12 April 2007; examined July 2008. Wing formula: primary tips heavily worn due to captivity and difficult to measure: p10 (outer) longest by 1.0 mm > p9 [or = p9]
- Bird 3 Suva Museum (F605), collected 3 July 1985; examined July 2008 (wet specimen and difficult to obtain precise measurements). Wing formula: p10 (outer) longest by 2.0 mm > p9
- Bird 4 In possession of DW, collected January 2009; examined May 2009. Wing formula: p10 (outer) longest by 3.5 mm > p9

seen. They do not project past the tail, ending far from the tip, and appear heavy and powerful (Fig. 3). The long tapering undertail-coverts reach the tail tip. In Fiji’s seas, the species with the closest total length and wingspan to Fiji Petrel is Black Noddy *Anous minutus* (total length c.34 cm, wingspan c.76 cm), which is very frequently seen. No other petrels are directly comparable in size to Fiji Petrel, with perhaps only Collared (very frequent) and Black-winged Petrels *Pterodroma nigripennis* (rare) having a similar total length (c.29 cm), but their wingspans, at max. c.70 cm, are much shorter. These *Pterodroma* also possess a relatively shorter rear body and tail, and thus different overall shape. Amongst familiar tubenoses of the Pacific, Fluttering Shearwater *Puffinus gavia* has the nearest total wingspan (76 cm). Fiji Petrel, to some degree, is closer in size and structure to Beck’s Petrel *Pseudobulweria becki* (HS and TP pers. obs. in Bismarck archipelago, Papua New Guinea) due to the relatively smaller size, more delicate structure, longer neck and narrower wings of *becki* in relation to *rostrata*. It too shares the squarer head and bulbous compressed bill, but *becki* lacks the distinctive tapering rear of Fiji Petrel.

Jizz and flight.—Fiji Petrel has several flight modes like those of *rostrata* and behaves similarly. However, being noticeably smaller and slimmer it is visibly more elegant. It flies effortlessly on characteristically long, narrow, pointed wings. When gliding (Figs. 3–5) into the wind, the wings are held rather stiffly and seemingly straight. Seen head-on, or from the rear, they are held slightly below body level, which forms a shallow arc in shape. The wingbeats are very relaxed and supple, appearing sometimes loose and languid. Even in ten-knot winds there were only a few shallow flaps. To our eyes, Fiji Petrel is not a particularly fast or energetic flyer. Only when the species was ‘excited’, near ‘chum’, was there clearly a more rapid pace with shorter wingbeats, swooping glides and more erratic changes of direction. Nevertheless, like gadfly petrels, arcing and banking (Fig. 3) can be

impressive. We never observed any in really strong winds or rough seas, but one bird performed rather high arcing (up to *c.*15 m above the surface), like a *Pterodroma*, in direct flight (bird 1). In comparison, the larger and heavier Tahiti Petrel's flight involves much longer and higher glides and arcs. We never observed Fiji Petrel in calm conditions. With its slim dark body and long wings outstretched, a Fiji Petrel at distance shows a unique silhouette (Figs. 3 and 8), yet when investigating the 'chum' the long neck and rear body were more obvious (Figs. 5 and 7), illustrating the variation in posture. The spread wings in lateral profile can appear rounder, but this is due to foreshortening.

Plumage.—Fiji Petrel is uniformly dark brown (Figs. 3–4, 6 and 8). However, in certain lights and at various angles, some subtle shades and coloration patterns were perceptible. We also noted some slight variation between individuals. The head and body appear blackish brown in overcast conditions or when distant, but medium to richer and brighter brown in sunlight and close views (Fig. 7). The head and breast usually appear a shade darker than the rest of the body, but this is not always visible, and does not create any contrast. A small ill-defined dark loreal mark is usually apparent (Fig. 7). The underparts, below the breast, often possess a very slight rusty hue, whilst some of the paler feather bases can be exposed, forming diffuse and asymmetric barring (Figs. 5 and 7). Both the degree of rusty shades and barring can be subtle and vary individually. The vent to undertail-coverts often appears slightly darker than the belly. The upperparts and upperwing lack any distinct pattern and are generally concolorous (Figs. 4 and 6). In certain lights the back and scapulars, and especially the lesser coverts, secondaries and five outermost primaries, are darker brown, with the bulk of the remaining coverts a slightly paler and richer brown. There is no pale carpal bar, or dark 'M' across the open wings, which several dark gadfly petrels possess. The underwing is somewhat plain brown, mirroring to a degree the upperwing with slightly darker / blacker lesser coverts, axillaries, secondaries and five outermost primaries (Figs. 3 and 5). The concealed bases and part of the webs of the greater coverts and the two largest rows of median coverts are diffusely greyer. When the wing is fully stretched or the coverts disturbed, for example by the wind, the bases are more visible and in some lights can show as pale areas, even as a ragged mid-wing band (Figs. 5 and 7). This effect, of a pale underwing panel, is illusory but can be brighter (and more apparent) when there is strong light reflection off the water or in captured birds, when the underwing-coverts are disturbed and camera flash heightens the falsity. Adults may show this pale band more extensively, though this might be due to individual variation and the number of feather bases and webs visible at the time. *Contra* Onley & Scofield (2007) we have not seen any birds in the field, or hand, showing a 'silvery sheen to flight feathers and outer wing-coverts' nor any 'pale lustre to the underwing' though this 'silvering' appearance can be common on many gadfly petrels, especially those in fresh plumage seen in bright light. The tail is concolorous with the uppertail-coverts and rump, or perhaps subtly darker, and shows no pattern.

Bare parts.—Based on our observations and photographs both at sea and in the hand, the bill and irides are blackish and the tarsi mostly pinkish flesh with a variable pale bluish tinge (= bluish-pink). Dorsally, the feet are mostly dark brownish black, from the outer side of the tarsus near the foot and over the whole outer toe. On the middle toe, the black coloration covers *c.*50% but on the inner toe just the tip. The base of the webs is pink, and the colour of the inner toe and basal half of the middle toe a purer blue, which coloration is clearly visible in images of birds with the folded feet exposed (Fig. 3).

Ageing and moult.—Examination of the moult of six grounded Fiji Petrels (1984–2009: see Appendix 1), and the four birds photographed at sea suggest the following. *Juvenile*—Of the ten birds, only 'grounded bird 6' can be certainly aged as a recently fledged juvenile. Like other petrels, at this stage the plumage is fresh and evenly feathered with no signs of



3



4



5



6

Figure 3. Fiji Petrel *Pseudobulweria macgillivrayi*, off Gau, Fiji, 13 May 2009. Bird 2 showing ventral side while arcing. Note typical *Pseudobulweria* structure; relatively large bill, proportionately long wings and slim elongated rear end. In natural light the entire underparts, fore and inner underwing-coverts and axillaries are dark brown whilst the remiges are fractionally paler / greyer, with no apparent pattern below (Hadoram Shirihai)



Figure 4. Fiji Petrel *Pseudobulweria macgillivrayi*, off Gau, Fiji, 13 May 2009. Another photograph of bird 2 while gliding, showing dorsal coloration to be generally concolorous and lacking any pattern (Hadoram Shirihai)

Figure 5. Fiji Petrel *Pseudobulweria macgillivrayi*, off Gau, Fiji, 13 May 2009. Another photograph of bird 2 during its slow flight investigating the 'chum slick'. The slim elongated body with tapering rear end, and particularly long slim wings, are evident. The underwing is virtually uniform, lacking any distinct pale elements, and the underparts show a very slight rusty hue with some paler feathering giving a subtle effect of diffuse barring (Hadoram Shirihai)

Figure 6. Fiji Petrel *Pseudobulweria macgillivrayi*, off Gau, Fiji, 13 May 2009. Bird 2 in profile; gentle wing flapping during a shallow glide. Note the sharp forehead, relatively large bulbous bill, and slim, very pointed rear body and tail. The outermost two secondaries are new, appearing darker, suggesting it is at least second-year or older, and possibly adult (Hadoram Shirihai)

Figure 7. Fiji Petrel *Pseudobulweria macgillivrayi*, off Gau, Fiji, 17 May 2009. Bird 6 flying low over the water, showing how in sunny conditions the plumage appears richer brown. The wing-coverts can appear misleadingly pale, even creating an underwing panel, which is an illusory effect due to light reflecting off the water surface (see text). Further images of the same bird show it lacking the pale panel effect (Hadoram Shirihai)

Figure 8. Tahiti Petrel *Pseudobulweria rostrata* (front) with Fiji Petrel *P. macgillivrayi*, off Gau, Fiji, 13 May 2009. Bird 2 in the background, behind the much larger and heavier Tahiti Petrel. Despite being much smaller, note Fiji Petrel's distinctive silhouette with slim body, elongated thinly pointed rear section, and very long narrow wings (Jörg Kretzschmar)

wear, abrasion or earlier generation feathers. *Immature and adult*—The other nine (five grounded and four at sea) belong to these age classes. All show, to varying degrees, mixed-generation feathers, although in most many of the remiges and rectrices are of the same generation. Four birds ('grounded birds' 1 and 5, and birds 1 and 6) have 2–3 newer (fresher / darker) outer secondaries, and one has a single fresher inner primary. If no moult occurs in the first year (like most petrels) we can affirm that most of these birds are second-year or older. We suspect that adults will undertake a complete post-breeding moult with limited or no feather retention. However, because we know virtually nothing about the biology of Fiji Petrel, to confirm moult sequence and changes in moult pattern through age, two options exist. Either these are non-breeding immatures (second-year or older) or breeding adults that appear to have completely moulted during the post-breeding (or a non-breeding) season, with recent additional or delayed and restricted partial (suspended?) moult just prior to the next breeding season. The only bird in active moult of the remiges is 'grounded bird' 4, which had some unmoulted flight-feathers and coverts of weaker and softer texture (probably juvenile-retained); it was probably undertaking its first complete moult. Without handling the bird (and further knowledge of the species' moult and ageing) its age is best considered uncertain.

Field identification

This depends on an ability to critically judge true size, colour and structure, whilst taking into account the effects of light and other conditions, and the observers' experience with other species. Fiji waters attract an assortment of dark species of petrels and shearwaters (see Appendix 3). Those that could be confused with Fiji Petrel, even by the most experienced observer, are discussed below. Suspected Fiji Petrels away from Fiji waters will be difficult to prove unless well photographed and their size evaluated through direct comparison with nearby petrels.

Potential confusion with seabirds common in Fiji waters.—Several locally breeding seabirds are dark or chiefly dark. *Tahiti Petrel*—Given reasonable views is unmistakable, and its much larger size and white belly easily identify the species from Fiji Petrel. However, Tahiti shares several structural and flight characteristics with Fiji Petrel, and when size and colour are difficult to judge, this species should be considered. At first glance, a Tahiti sometimes looks small and darker overall and the white belly can be invisible, due to the combination of bright sunlight and distant views. *Collared Petrel* (dark morph)—Again, unlikely to be confused with Fiji Petrel, unless seen briefly or distantly. The white forehead and throat, and mostly white underwing with narrow dark diagonal bar, eliminate Fiji Petrel. Frequently, we had extremely dark examples of Collared approach the boat in low flight and side view, thereby revealing neither the underwing nor the rounder, shorter wings, and appearing initially like an all-dark small petrel. *Brown Noddy* *Anous stolidus* and *Black Noddy*—Despite being terns, these mostly brown to dull black seabirds are also slim and long-winged. Often they perform short, petrel-like, glides, but their typical shape and almost constant flapping flight should be swiftly apparent. At closer ranges, the thin tern-like bill and whitish cap are evident.

Bulwer's and Jouanin's Petrels.—Any claim of Fiji Petrel needs to be critically separated from the two *Bulweria* petrels, *Bulweria bulwerii* and *B. fallax*. Both these graceful flyers have long slim wings and distinctly elongated rear bodies, as well as all-dark plumage. Bulwer's is widespread in tropical oceans, but seems rare off Fiji and in nearby waters, whilst Jouanin's occurs mostly in the western Indian Ocean, though vagrants have been reported off Western Australia three times (www.users.bigpond.net.au/palliser/

barc/case349.html; www.users.bigpond.net.au/palliser/barc/case363.html; www.users.bigpond.net.au/palliser/barc/SUMM458.html) and twice in Hawaii (Seto *et al.* 1996). These *Bulweria* often possess a diagnostic pale panel on the greater upperwing-coverts, but this is highly variable and can alter with angle and light, as well as feather wear. Our observations (HS and TP) show that many *Bulweria* can possess a reduced pale panel, indeed so reduced on some to appear lacking! Identification must rely on correct evaluation of size and shape: compared to Fiji, Bulwer's is smaller with shorter wings (total length c.27 cm, wingspan c.70.5 cm) but the larger Jouanin's is closer in size to Fiji (total length c.31 cm, wingspan c.79 cm). Experienced observers should differentiate Fiji Petrel and the two *Bulweria* by their characteristic flights. Fiji Petrel, a *Pseudobulweria* with proportionately longer wings held stiffly, has a less erratic flight, whereas *Bulweria* fly low to the water, zigzag, change height and alter direction rapidly with short glides and arcs. In close views, *Bulweria* have rather smaller, squarer shaped, storm petrel-like heads, with a high forehead and a bill clearly narrower than in Fiji Petrel. We should emphasise that correct evaluation of bill structure at sea requires prolonged and close observation, but can be assessed up to 100 m away, even further in especially favourable conditions. Also, when *Bulweria* are seen in profile, with the tail fully folded, the projection of the rear body and the tail, beyond the wings' trailing edge, is almost (up to) double that of the fore body to the bill tip, forward of the leading edge (in photographs, 50–90% longer). In Fiji Petrel the rear section is only c.30% longer. However, these proportions should be used cautiously: for example, the tail of *Bulweria* can appear misleadingly shorter due to wear, and the profile of a flying bird may alter with its flight mode. Furthermore, in *Bulweria* the rear body and tail taper less abruptly than in Fiji, and the bodies of both, especially Jouanin's, appear slimmer and flatter bellied, resulting in a straighter profile.

Christmas (Kiritimati) Shearwater.—Tropical Pacific *Puffinus nativitatis* is probably rare in Fijian waters (see Appendix 3), but as likely to be encountered as Fiji Petrel. During extensive observations, HS found that this species is the most likely to be confused with Fiji Petrel. It is almost uniform dark brown, with a similarly indistinct colour and pattern, e.g. a slight rusty tinge to the body that Fiji Petrel also possesses. It has a similar wingspan (c.75 cm) and, despite being short-tailed, also has a tapering rear body, with the folded tail narrowing to a point, which profile resembles Fiji Petrel. *Contra* most literature, this shearwater sometimes flies languidly with slow and easy flaps, and shallow glides, on slim and supple wings. It is essential to check bill structure and confirm if this is thin and typical of a shearwater, or thick, bulbous and petrel-like, although this might not always be easy. Christmas Shearwater has an angular head profile, like many *Puffinus*, and tends to show pale upperwing-covert fringes, as well as having feet that project slightly beyond the tail. When this shearwater is seen well, Fiji Petrel is easily dismissed.

Mascarene Petrel.—All-dark *Pseudobulweria aterrima* may be the closest relative of Fiji Petrel and is the second-largest *Pseudobulweria* (total length c.36 cm, wingspan c.88 cm). It is known only from Réunion in the western Indian Ocean and, because it is very rare, the possibility of it reaching Fiji waters is unlikely. However, the possibility of vagrancy of Fiji and Mascarene Petrels to the south-west Pacific and south-east Indian Oceans (e.g. off southern or south-east Australia) cannot be excluded. Only one of us (HS) has seen Mascarene, both as specimens and at sea, though all of us have examined photographs of grounded birds from Réunion. On present, admittedly very limited, experience, we believe that they are virtually identical in structure and plumage, but they differ markedly in size. Claimed records of either species away from their breeding islands must pass a very stringent size evaluation.

Taxonomy

The genus *Pseudobulweria* was initially erected for Fiji Petrel by Mathews (1936). The species' genetic relationships are currently unknown, although *macgillivrayi* is currently being sequenced together with *aterrima*, *rostrata* and *becki* (Bretagnolle *et al.* in prep. b), which will classify for the first time all four *Pseudobulweria*. Bretagnolle *et al.* (1998) confirmed the validity of *Pseudobulweria*, showing it to be sister to *Puffinus* and *Calonectris*, which genera in turn are most closely related to *Bulweria* and *Procellaria*. Our observations confirm that structurally and behaviourally Fiji Petrel is correctly placed in *Pseudobulweria*, and that it shares many features with the much larger *rostrata*. Measurements of the four Fiji Petrel specimens appear in Table 1. To compare these with other taxa in *Pseudobulweria* refer to Villard *et al.* (2006) for *rostrata*, Attié *et al.* (1997) for *aterrima*, and Shirihai (2008a) for *becki*.

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APPENDIX 1: Previous records of grounded Fiji Petrels

Priddel *et al.* (2008) detailed past records of Fiji Petrel. We add new information from recent examination of all museum specimens and photographs of collected or grounded birds. New data, especially concerning

moult and ageing, add to deliberations on the breeding season. Previous records of grounded birds were important in planning our work (see Methodology).

Holotype.—The medical doctor aboard *HMS Herald*, Dr F. M. Rayner, obtained the holotype, which is held in The Natural History Museum (Tring), during a visit to Gau in October 1855. Bourne (1965, 1981) and Imber (1985) reported that it was a recently fledged juvenile, with flight-feathers not fully developed and non-fused pre-frontal skull morphology, which interpretation was accepted by Priddel *et al.* (2003, 2008). M. J. Imber (*in litt.* 2009) also referred to his notes, wherein he had recorded that the specimen had some down feathers, but these now seem to be lacking (perhaps lost during subsequent handling). However, recent examination by HS revealed that the bird appears to lack fresh plumage, with very worn and bleached greater upperwing-coverts. Lack of any moult contrast (i.e. different feather generations) often does indicate a juvenile petrel, and both W. R. P. Bourne (*in litt.* 2009) and M. J. Imber (*in litt.* 2009) thought that wear on the coverts could be explained by nesting burrow abrasion and / or poor handling. However, unlike the strong wear of this particular specimen, the most recently grounded fledgling (January 2009) has typically very fresh plumage, including all wing-coverts. The extent of wear in the type is similar to another HS examined, an adult (or at least second-year) from April 2007 (see below). These uncertainties and current lack of knowledge of moult and ageing of the species, and *Pseudobulweria* as a whole, hinder the theory that the holotype is unquestionably a fledgling. If it is a juvenile, then the relatively small size could be explained by it being a male. Conversely, if it is not a juvenile, questions arise as to why an adult male is the smallest of the four available specimens. We are unsure if the fact that $p9 > p10$ in the holotype can be attributed to the flight-feathers being not yet fully developed, as the fledgling (2009) had $p10$ longest like the adult / immature (2007). Interestingly, the four birds photographed at sea had wing formulae like the type ($p9 > p10$). The simplest explanation to the above discrepancies is that the specimen is a fledgling, as both Bourne and Imber concluded, but with exceptionally abraded coverts. We recommend that the type specimen be checked again and be compared genetically with recent specimens, to remove lingering doubts. See Table 1.

Grounded birds on Gau.—1965: A Fiji Petrel landed in Nukuloa village, and was examined by KM and B. Palmer, the head of the Fiji Museum at the time, but unfortunately no specific date is known, and no photographs or measurements were taken. Priddel *et al.* (2008) regarded this record as acceptable.

1984: DW had the extraordinary experience of a bird crash-landing into him while spotlighting on 30 April (Watling & Lewanavanua 1985). In our view this record ('grounded bird' 1) marks the rediscovery, after c.130 years, as it was confirmed with photographs and measurements. To the islanders of Gau Fiji Petrel was never a 'lost bird' and Ratu Filipe Lewanavanua, paramount chief of Gau, had much influence, including spiritual, in the belief that the petrel awaited rediscovery (Watling 1986c). Photographs reveal it was probably an adult (or immature, second-year or older): the left wing has two newer and distinctly darker outer secondaries and there appears to be mixed feather generations in the upperwing-coverts and upperparts. The plumage is moderately worn on the greater coverts and primary tips and, if a breeding adult, suggests the bird was caught early in the breeding season.

1985: In April or May, a Fiji Petrel was reported in Nukuloa village but there are no further details. A second bird ('grounded bird' 2) flew into lights at Nukuloa on 3 July 1985 and died a week later. It was deposited in the Fiji Museum by DW, and preserved in formalin. In July 2008, this specimen was re-examined by HS but it was difficult to inspect moult and to age the bird, though overall the plumage, including the primaries, appeared rather fresh with no apparent moult limits or gaps in wing or tail. According to Priddel *et al.* (2008), W. Boles, Curator of the Ornithology Section at the Australian Museum, aged it as young adult female that had not bred yet (the oviduct was thin and straight, and the ovary, 5×3 mm, smooth). Thus, it could have been a non-breeding adult or immature, perhaps making an early exploration of the island.

1987–2001: Priddel *et al.* (2008) listed six petrels crash-landing onto roofs in Nukuloa and Nawaikama villages, but none is documented photographically and no measurements were taken. These include four that Priddel *et al.* (2008) regarded as confirmed (examined by KM): two in 1987 (30 July and 11 October); one in 1989 (18 December); and one in 1990 (no date). Two later ones, considered doubtful, involved singles in 1990 (no date) and December 2000. Only three, those in 1987 and 1989, were released safely back to the wild.

2002: On 29 December, a Fiji Petrel landed on a roof at Nukuloa village. It was photographed ('grounded bird' 3), unfortunately died and was not retained. Image quality is too poor to permit moult assessment and ageing, but HS considers it to be possibly an adult (or an immature, at least second-year), based on contrasting feathers in the wing and body, suggesting different generations, apparently noticeably worn greater wing-coverts, and what appears to be highly bleached outer primary tips. Also in December a bird was reported to have landed at Lamiti, the only record from eastern Gau. It apparently died and was not retained. Priddel *et al.* (2008) reviewed this incident with scepticism.

2003: There are unconfirmed reports that possible Fiji Petrels grounded in June, one in Lovu and the other at Nacavanadi. Neither village has had grounded birds in the past, or since, and details are lacking. Priddel *et al.* (2008) were sceptical of both records.

2005: On 4 May two were seen in Sawaieke village. One flew off the same evening and the other, captured by local children and of which several photographs exist, was released next day ('grounded bird' 4). It is the only record of two together. Examination by HS of the photographs show that the bird was in progressive moult, missing three inner primaries on both wings and had a growing primary visible on the right wing. Separate feather generations were noted on the body, upperwing-coverts and tail. The older unmoulted feathers appear weak, and of softer texture, and could be juvenile-retained. The bird may have been adult (Priddel *et al.* 2008), but it is unlikely that it was a breeder given moult stage. It may have been a non-breeding immature whose moult would be earlier than breeders. Conceivably, both birds were inexperienced, returning perhaps for the first time, and having limited familiarity of the island were more likely to become disoriented by village lights.

2007: On 12 April, a bird landed in Levuka village. This individual was kept in captivity but died on 19 April ('grounded bird' 5). In August 2007, while processing the specimen, W. Boles (*in* Priddel *et al.* 2008) concluded it was an adult female that had not yet bred. Examination by HS revealed the following: all remiges appear to be single generation and are slightly to moderately worn, but the longest primary tips are very worn (probably due to poor handling). Greater secondary-coverts and some tertials are considerably worn. Among the tertials and scapulars there are single new feathers and on the left wing one secondary is new; these are much blacker and clearly distinct from older feathers. The greater secondary-coverts are heavily worn and bleached, and conceal the fresh greater primary-coverts. Thus again, it was possibly a non-breeding adult or immature (second year or older) that had moulted completely with recent additional, delayed and restricted partial (suspended?) moult, just prior to the next breeding season.

2009: One in Levuka village on 19 January 2009 died shortly afterwards ('grounded bird' 6) and was transferred to DW in Suva. Partially frozen, it was examined by HS. The examination revealed all remiges and rectrices to be very fresh and of the same generation, but with very minor wear, and the greater-coverts had a paler brownish tinge, perhaps due to some wear as a nestling. It had a few downy feathers on the crown and neck-sides, so clearly was a recently fledged juvenile.

APPENDIX 2: Past records and efforts to see Fiji Petrel at sea

Past claims at sea.—Priddel *et al.* (2008) re-examined claimed records (all post-1960) and concluded that none is substantiated. These included four observations of small dark petrels that could have been Fiji Petrels (8 November, 31 December 1964, and 1 January, 23 May 1965; summarised in Bourne 1965), but might have been Bulwer's Petrel. Also included was an unconfirmed record, from 12 June 1986, by DW of a bird near the reef off north-west Gau. Onley & Scofield (2007) noted Fiji Petrel 'at sea near Gau and from 200 km north of Gau but believed to disperse to pelagic waters far from the island'. We cannot confirm or deny this statement and we are uncertain if the same source made the comment 'pale lustre to the underwing' in their description (see Plumage). We agree with Priddel *et al.* (2008) that there were no genuine records of Fiji Petrel at sea, prior to ours in May 2009.

Recent records of Fiji-like Petrels elsewhere.—Shirihai (2008a) described three dark petrels observed in the Bismarck archipelago, Papua New Guinea, which were noted as 'Fiji-like Petrels'; one in August 2003, one in July 2007 and another in August 2007. All three had a *Pseudobulweria*-like structure, resembling Beck's Petrel in shape, but two seemed slightly smaller overall, despite appearing more robust, larger headed and particularly heavier billed. Plumage was predominantly dark brown, slightly darker on the head / face, and they had fractionally paler fringes to the upperwing-coverts, though these did not create a carpal bar. Underwing was almost uniformly dark, perhaps with a paler / greyer tone, though this was partially attributed to the effect of strong sunlight. Until now, there were no photographs or even a basic description of Fiji Petrel's appearance and behaviour at sea for comparison. Shirihai (2008a) cautiously regarded these sightings as uncertain; they could even represent an undescribed *Pseudobulweria*. Following the 2009 expedition HS can confirm that on shape and flight behaviour, especially jizz, the Bismarck birds were not the same, and prefers to retain them as 'unidentified dark *Pseudobulweria* petrels'. Howell (2007) saw an unidentified dark petrel, suspected by him to be Fiji Petrel, in the same general area in April 2007. On the Western Pacific Odyssey cruise, April 2008, another all-dark petrel was logged, but we cannot validate either sighting without further details from Howell and the other observers aboard.

Previous attempts to find Fiji Petrel at sea.—Aside from the efforts to locate Fiji Petrels ashore on Gau (Watling & Lewanavanua 1985, Priddel *et al.* 2008), three earlier attempts targeted Fiji Petrel at sea. DW chartered a yacht and searched Gau waters unsuccessfully for a week in 1986. HS arrived in Fiji on 17 July 2005 for three weeks, to search the archipelago, especially around Gau. The *Turagalevu* was chartered and the 'chum' loaded, but the weather was unusually rough, with frequent rain and storms, and the expedition could only operate on a few days. In July 2008, HS, TP, JK and DW (with others from the UK, Australia and Sweden) made a third attempt to locate Fiji Petrel at sea, this time using the *Summer Spirit* with two tonnes of 'chum' aboard. This journey was aborted after just three days due to mechanical problems with the boat. Two 'chumming' sessions did produce six Kermadec Petrels and two Polynesian Storm Petrels *Nesofregatta fuliginosa*. Twice, some of the team saw a 'Cookilaria-sized' dark petrel. The first 'chumming', south-west of Gau, recorded a steady stream of petrels, mostly Tahiti and Collared Petrels, moving in the direction of breeding islands further north in the archipelago (Fig. 1). Following the boat's technical problems, the team flew to Taveuni to try for seabirds there and, whilst aboard the *HiFlyer*, recorded White-bellied Storm Petrel *Fregatta grallaria* and at dusk a gathering of Tahiti Petrels in the Somosomo Strait, waiting to return to their burrows ashore.

APPENDIX 3: Other tubenoses recorded in July 2008 and May 2009

A passage of petrels was noted, apparently from feeding grounds south of Fiji (Fig. 1). The vast majority were Tahiti and Collared Petrels but other less common species were involved. Since this passage occurs mostly after 14.00 h, during late afternoon and evening especially, we assume it involves mostly birds breeding on nearby islands: on Gau (Collared Petrels) and islands further north (Tahiti and Collared Petrels). In the context of finding Fiji Petrels at sea, we saw great advantage in that this 'rush hour' occurred near Gau (see Methodology). We collected data on the timing and number of these birds, as well as weather patterns, for a future publication wherein we will discuss the relationship of weather to these movements. For now, we note that this passage is changeable and can drift further east of Gau. Highest numbers of individuals and diversity of species occur in south-east winds and extensive cloud cover, but in sunny conditions and winds from the north or west we found the sea lacking in tubenoses. This area might prove to be a 'hotspot' for seabirds, and further work should increase our knowledge of some of these species. Table 2 provides daily (conservative) estimates for each species and maximum counts in 2009, mostly during 'chumming' (see Methods), with notes on each species included below; current status in Fijian waters comes from the records of DW.

Murphy's Petrel *Pterodroma ultima* One photographed on 16 May 2009. There are no known records from Fiji and the literature (e.g. Murphy 1930, Murphy & Mowbray 1951, Murphy & Pennoyer 1952, Bourne 1965, Bourne & Dixon 1971, Marchant & Higgins 1990) suggests this record is also the first for the Western Pacific. This is an extraordinary record of vagrancy by a species that breeds no closer than the western Tuamotu archipelago (HS pers. obs.), 2,000 km east of Fiji, and usually migrates north and east of the breeding islands. The typical underwing pattern, duskier hood, scaly upperparts with bluish-grey tinge, and well-developed dark upperwing 'M', make this record undeniable. The photograph was compared with HS's photo collection of *ultima* (>300 birds) from Henderson and Oeno islands.

Kermadec Petrel *P. neglecta* Birds varied from very pale to all dark. It breeds as close as the islands of Kermadec, Lord Howe and Tonga, but is a vagrant to mainland New Zealand and eastern Australia. We observed it in 2005, 2008 and 2009 and believe it to be regular in Fiji waters, and that it may breed. Characteristic feeding behaviour, chasing other petrels in the manner of skuas, was observed. The dark morph is easily separated from Fiji Petrel by its distinctly larger size, broader wing and shorter and rounder tail. Even the darkest examples show white primary bases (lacking in Fiji Petrel).

Phoenix Petrel *P. alba* One on 21 May 2009 apparently is the first confirmed record for Fiji waters. Observers may be confused with respect to variation within the Herald Petrel *P. heraldica* complex, and the species seems always to be compared directly with Tahiti Petrel. This is misleading, though frequently repeated even in recent literature, e.g. Onley & Scofield (2007). A full review of the identification and variation of the *neglecta-heraldica-alba* complex will be given in Shirihai & Bretagnolle (in prep.).

Mottled Petrel *P. inexpectata* This long-distance migrant moves from breeding grounds in New Zealand to the North Pacific, but has seldom been recorded in Fiji waters. It was seen (and photographed) almost daily in 2009.

White-necked Petrel *P. cervicalis* One briefly inspected the 'chum' on 18 July 2008. The bird might have been a Vanuatu Petrel *P. occulta*, although it was seen alongside several other species and appeared too large.

TABLE 2

Daily counts of Procellariidae in 2009. Numbers in parenthesis refer to maximum numbers of birds seen together, at 'chum'. Details of individual count sessions with species / numbers are available from the authors. Note: 12 May data refer to observations en route between Suva, Viti Levu, to Gau Island.

	12 May	13 May	14 May	15 May	16 May	17 May	18 May	19 May	20 May	21 May	22 May
Murphy's Petrel <i>Pterodroma ultima</i>					1						
Kermadec Petrel <i>P. neglecta</i>			1	4	1					2	2
Phoenix Petrel <i>P. alba</i>										1	
Mottled Petrel <i>P. inexpectata</i>		>2	1	3	2		3	1	1	2	
Black-winged Petrel <i>P. nigripennis</i>			1		1						
Gould's Petrel <i>P. leucoptera</i>		6	>5	6	1	3			1	2	2
Collared Petrel <i>P. brevipes</i>		>80 (13)	>40 (12)	>40 (5)	>60 (12)	>80 (8)	>40 (6)	>5	>10 (3)	>15 (4)	>100 (13)
Tahiti Petrel <i>Pseudobulweria rostrata</i>	1	>100 (11)	>50 (8)	>70 (12)	>100 (14)	>70 (14)	>50 (12)	>10	>15 (4)	>35 (4)	>100 (17)
Fiji Petrel <i>P. macgillivrayi</i>		3	1		1	2	1				
Parkinson's (Black) Petrel <i>Procellaria parkinsoni</i>						1					
Christmas Shearwater <i>Puffinus nativitatis</i>	1										
Wedge-tailed Shearwater <i>P. pacificus</i>		15 +/-		2		1	6	2	1	1	2
Buller's Shearwater <i>P. bulleri</i>		1									1
Sooty Shearwater <i>P. griseus</i>		1		3	1	1	2 +/-	1	2	2	1
Flesh-footed Shearwater <i>P. carneipes</i>										1	
Wilson's Storm Petrel <i>Oceanites oceanicus</i>			3 (2)					1	1		1
White-faced Storm Petrel <i>Pelagodroma marina</i>					1						
Black-bellied Storm Petrel <i>Fregatta tropica</i>					1						
Polynesian Storm Petrel <i>Nesofregatta fuliginosa</i>			1								
Matsudaira's Storm Petrel <i>Oceanodroma matsudairae</i>		1									

Vanuatu Petrel has been identified once at sea only, between New Caledonia and Vanuatu, in January 2006 (HS). Both species can be expected in Fiji waters.

Black-winged Petrel *P. nigripennis* Two; one in fresh plumage, the other in heavy moult. The species' status is uncertain in Fiji waters, where it is little known, despite breeding as close as New Caledonia, Tonga and the Kermadec Islands.

Gould's Petrel *P. leucoptera* A few seen, almost daily, amongst the many *P. brevipes*, with which it was considered conspecific in the past. All were *P. l. caledonica*. The paucity of records in Fiji waters may be attributable to a lack of knowledge in separating it from pale-phase *P. brevipes*. The possibility that *P.*

leucoptera also breeds in Fiji cannot be excluded as, apart from New Caledonia, Cabbage Tree Island (off New South Wales, Australia), and possibly Vanuatu, the species has now been found breeding far to the east, in south-east (French) Polynesia (Bretagnolle *et al.* in prep. c).

Collared Petrel *P. brevipes* Numbers increased during the late afternoon, suggesting most were breeders from Gau. Notes on plumage variation will be published in Bretagnolle *et al.* (in prep. c) and Shirihai & Bretagnolle (in prep.); 10% were dark-bellied birds (17% noted by Watling 1986a).

Tahiti Petrel *Pseudobulweria rostrata* The most frequent petrel. Most are believed to breed in northern Fiji, e.g. on Taveuni. In the area surveyed this large petrel was the most dominant and aggressive at 'chum'. Although recorded ashore on Gau (Plant *et al.* 1989), breeding has not been recorded and we did not see Tahiti Petrels massing off Gau in the evenings, in either year. If it does breed it could be a potential competitor with Fiji Petrel for burrows.

Parkinson's (Black) Petrel *Procellaria parkinsoni* Our observation (Table 2) of this New Zealand endemic breeder is the first for Fiji waters.

Christmas (Kiritimati) Shearwater *Puffinus nativitatis* A bird seen en route to Gau (12 May 2009) is the second for Fiji waters.

Wedge-tailed Shearwater *P. pacificus* Breeds on many islands in Fiji, including Gau, but relatively few seen (Table 2), all of the dark morph, and we are unaware of pale forms in the region. The inexperienced observer could confuse dark *pacificus* with Fiji Petrel, but it is a typical shearwater with a long slim bill, and is distinctly larger. Distantly, or at first glance, Wedge-tailed can show a petrel-like silhouette but we never found size problematic to judge.

Buller's Shearwater *P. bulleri* Observed on two days in 2009. Only three previous records in Fiji waters.

Sooty Shearwater *P. griseus* Few seen on most days. Some showed quite dark underwings, had apparently short bills, and their feet projected beyond the tail in flight. We mistook some as Short-tailed Shearwaters *P. tenuirostris* and these odd birds require future attention. Both shearwaters are regular in Fiji waters. Sooty Shearwater is also readily distinguished from Fiji Petrel by its much larger size, typical shearwater shape and flight, long thin bill and shorter tail. Most show pale panels on the underwings, unlike Fiji Petrel, but confusingly some are virtually all dark. Perhaps, in brief and distant views, or for inexperienced observers, these could be confused, albeit briefly.

Flesh-footed Shearwater *P. carneipes* Surprisingly, our 21 May 2009 sighting is only the second in Fiji waters; the first was a bird captured off Gau, in February 2009 (NFMV 2009b). Despite its almost uniform body and underwing, the species should be easy to separate by its large size, proportions, and long thin bill with pinkish base.

Wilson's Storm Petrel *Oceanites oceanicus* Observed on four days, always at the 'chum'.

White-faced Storm Petrel *Pelagodroma marina* A single at the 'chum' on 16 May 2009 had the pale, virtually whitish-grey, rump apparently associated with *P. (m.) albiclunis*, which breeds on the Kermadec Islands, New Zealand and possibly Norfolk Island, Australia. There are two previous records of this species from Fiji waters.

White-bellied Storm Petrel *Fregatta grallaria* We photographed the first for Fiji waters, in July 2008, off Taveuni Island.

Black-bellied Storm Petrel *F. tropica* One at the 'chum' on 16 May 2009, the second confirmed record in Fiji waters.

Polynesian Storm Petrel *Nesofregatta fuliginosa* This attractive storm petrel was first recorded in Fiji from a bird taken on the nest in September 1876 on Kadavu Island (Finsch 1877). There were no further confirmed records until 19 July 2008, when we photographed a bird at the 'chum', with another on 14 May 2009.

Matsudaira's Storm Petrel *Oceanodroma matsudairae* The first record for Fiji waters of this Japanese breeder (and Indo-Pacific migrant) was on 13 May 2009. The closest region where the species is regular is the Bismarck archipelago, Papua New Guinea.